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Measure of Resiliency of Information, Communication and Other Smart-Technologies in Underdeveloped Flood-Affected Communities

Izza Anwer[1] and Muhammad Irfan Yousuf[2]

[1]Department of Transportation Engineering and Management, University of Engineering and Technology, Lahore, Pakistan
[2]Department of Computer Science, University of Engineering and Technology, Lahore, Pakistan

ABSTRACT

The perceptions of flood affected individuals on the use of Information, communication and other smart technologies (ICSTs) to improve communication flow between themselves and the flood management authorities is a largely under-explored field, especially, for underdeveloped and highly flood prone communities. One of the challenges faced by the community is the lack of timely transportation systems and floods related information is the biggest challenge for all times. Historically, this lack of information has resulted in many causalities and major losses, establishing the rationale for the research question that "What types of ICSTs are used by the residents of emerging communities to attain transportation systems under floods' related information and what are the influencing factors". In total 1105 randomly selected households from the case-study were recruited to complete a questionnaire. A Multinomial Logistic Regression approach was employed to analyze the data. Seven different categories of ICSTs as dependent variables (DVs), and eighteen different independent variables (IDVs) based on the personal traits of individuals, socio-economic characteristics and awareness of the relevant authorities to contact for transportation systems and floods-specific information during flooding were modelled. Twelve IDVs were found to be significant in the model-fitting process and in total nineteen different statistically significant models were developed. The results illustrated perceived importance of each group of ICSTs according to different user categories. The research outcomes will contribute to the development of advanced ICSTs usage analytics driven policies and management frameworks, enhancing efficient transportation systems, search and rescue operations, evacuation strategies, and emergency logistics planning for flood-affected communities.

Keywords: Communities, Floods, Information Communication Technologies (ICT), Rescue and search operations, Smart technologies, Transportation systems

INTRODUCTION

Information, communication and other smart technologies (ICSTs) are in use all around the world and new technologies are emerging at an increasingly rapid pace (Grant-Muller and Usher, n.d.). ICTs are deployed in a number of

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ways to manage traffic, logistics, disaster management and even in combining different data sources (Zear et al., 2016). The role of ICT is particularly important when it comes to planning and managing transport systems and flood related activities e.g., evacuations, support transport related activities, services and information (Zear et al., 2016; Giovanna et al., 2016). The effective flow of transport information and communication can contribute to sustain resilience of transport systems under critical situations (Shafiq and Ahsan, 2014; Brian Houston et al., 2014; Faturechi and Miller-Hooks, 2014).

Floods are predictable but are dynamic in nature, as a result strategic planning and efficient management are needed for transport-flood activities that are diverse, difficult and span over a period of three stages i.e. pre, during and post-flooding (Chen et al., 2015; Jerry Velasquez et al., 2015). A major problem encountered in floods is that of broken communication links causing barriers to the timely flow of information. A lack of transport-flood communications at multiple platforms, amongst transport-flood management authorities and transport-flood affected people result in severe causalities and losses. With effective communications precious lives can be rescued in time (Brian Houston et al., 2014; Jerry Velasquez et al., 2015).

ICTs hold potential to be explored further, especially, related to disastrous scenarios (Giovanna et al., 2016), and for neglected communities who could be potential users of ICT (Gutman and Yon, 2014; Tribune, 2013; Societies, I.F.o.R.C.a.R.C., 2015). This paper focuses on aspects of information and communication flow (ICF) through use of ICTs that are available to, and usable by, the communities over three different stages of a flood. The objective is to create a deeper understanding of the perceptions of primary flood victims who have used ICTs for the exchange of transport-flood information. It is an important social and logistics issue to improve understanding of which types of ICTs are (or can be) utilized by flood affected people and with which technologies they are familiar with. Above all, technological adaptation to support operations under changing floods' circumstances and responsible variables are required to investigate. These questions lead to further examination of variables to determine the choices made by flood effected communities among different ICTs and whether those variables are consistent in effect over the three stages of a flood.

Methodology

To address the objective and research questions, this section reports the case study, sampling size, questionnaire design, data collection and profiles of floods affected community.

Case-Study Head-Marala (Sialkot, Pakistan)

The community of Head-Marala was chosen as a case-study. Head-Marala is a barrage (mini-dam) situated in the vicinity of Sialkot city, which is an industrial city of Pakistan. It is an under-developed community that has faced flooding for many decades (Awan, n.d.). Floods occur approximately every two years due to a rise in the water level of the river Chenab, mainly due to the seasonal monsoon (Awan, n.d.). Travel during floods tends to be restricted to that of a critical nature, such as evacuations, emergency, rescue, and search operations (ERSO), whilst logistics and resource distribution are always affected by the floods.

Residents of the Head-Marala have to evacuate the area in masses every now and then (Authority, D.D.M., 2008). Large scale ERSO are required, and the floods badly affect the transport system in the area. Though the community of Head-Marala is already familiar with floods of varying severities, different flood situations and their effects spanning over years. Government and other flood management authorities have specific expertise to tackle most difficult situations, but problems lie in the fact that there are limited resources and a dense population (Hashmi et al., 2012). Moreover, there is a lack of communication between the authorities and people (Authority, D.D.M., 2008) and a lack of timely transport-flood information. The plans in place to facilitate ERSO are ambiguous and are often not followed by the flood affected people. Previously (Anwer et al., 2016; Anwer, 2017; Anwer and Grant-Muller, 2017, 2017b) the author has initiated to discover the associations between ICTs, disasters and transportation systems in a combined frame as prior to that no such significant, detailed studies, have been published so far that can facilitate the traffic, travel behaviors and patterns followed by the flood affected low-incomed densely populated economies.

Questionnaire

To enable detailed data collection a questionnaire was designed and analyzed further. A questionnaire was designed carefully to test 18 Independent variables (IDV), The questionnaire was piloted and ethically approved by the Ethical Approval Committee of University of Leeds. The quality of the data collected was given priority. It took around 3-4 months to collect data. The information was collected for three different stages, i.e. pre, during and post flood. ICT were categorized into seven different groups to collect data of flood affected people of Head-Marala along with other variables such as technological use under various floods scenarios, severity, vehicles related information, personal traits etc.

Sampling Method and Data Collection

Highly flood exposed and experienced community members were recruited as a sample to analyze the effect of different variables to model choice behaviors using ICTs in a life cycle of floods. 1105 household samples were surveyed alongside the river Chenab, directly exposed to the flood water through random sampling.

Summary of Responses From Questionnaire

The sample was predominantly drawn from highly flood-affected locations, with 97.1% of respondents residing in moderate to highly affected (riverine) areas and 87.6% directly experiencing flood events. Despite 51.5% reported vehicle ownership, mobility autonomy remained constrained because 42.9% relied on boat/helicopter as evacuation mode which was operated by ERSO teams and 29.5% reported no evacuation occurrence for them. This reflects severe disruptions of surface transport networks. The demographic profile showed 59% males and 41% females, age group 26–40 years responded heaviest as 49.5%. 95.2% were university graduates and professionals that indicates well-informed and economically active cohort embedded within compromised transportation systems under floods.

Institutional communication and transport governance exhibited critical gaps across the flood cycle. Only 25.7% received official informational alerts and merely 8.6% contacted authorities, while preference for government authorities to seek help remained low as 24.8% compared to emergency/rescue services 59%. This implies weakened institutional trust and limited formal integration between early warning systems and transportation-dependent populations during extreme events.

Pre-flood conditions revealed moderate penetration of simple ICTs within transportation decision-making, 44.8% used landline/mobile phones, 42.9% relied on local news channels, and 57.1% engaged messenger platforms. However, advanced digital tools such as GPS trackers 9.5% and dedicated alert applications 24.8% remained underutilized, indicating limited preparedness for route optimization and real-time mobility adaptation under floods' exposure.

During floods, communication behavior shifted toward conventional and interpersonal channels. While 41.0% continued using landline/mobile phones, non-use of subscriptions increased to 59.0% and 53.3% reported no use of apps at all. Social media engagement declined to 48.6%. This suggests infrastructural breakdowns and network unreliability that directly constrains adaptive transportation choices ERSO and evacuations coordination.

Post-flood patterns demonstrated partial digital rebound yet stayed persistent with technological exclusion. Messenger usage increased to 63.8%, and subscription-based services rose to 26.7% for emails and 20% for phone network based. 57.1% still reported neither use nor non-availability of flood-related apps. This indicates that although communication networks recover faster than physical transportation infrastructure, the integration of smart mobility technologies into resilience planning remains structurally weak across pre, during, and post-flood phases.

Data Analysis Through Multinomial Logistic Regression

Multinomial logistic regression (MNLR) is used. MNLR is not new to ICT system technologies (Grant-Muller and Usher, n.d.; Muller and Whiteman, 2009; Chatterjee et al., 2002). However, the application of MNLR in the context of emerging transport system technologies in floods is yet to be investigated further. This research provides another opportunity (Anwer, 2016) to the use of MNLR at humanitarian level to identify the extent, use, availability and choice of ICT under floods. Table 1 shows those models that were developed between DV and IDVs. ICT was grouped into seven categories i.e. simple ICT, subscriptions, messengers, smart phone applications, social media public forums, social media websites and news channels. The reference category for all DVs is "Do not know" whilst for each IDV it varies and is explained in relation to reference category. The models were run many times to achieve best fit model, and, in the table, statistically significant categories are mentioned. Each group of ICTs (DV) is tested against different IDVs variables and are presented in the form of models. In total 19 models were established (including all three stages of floods). Not all the IDVs could develop model with DVs. Only those models are considered and information presented in table that presents marginal percentage criteria was satisfied (Tortora, 1978; Wedagama, 2009).

Table 1: Multinomial logistic regression analysis' results of three stages of recurrent floods in Head-Marala, Pakistan.

Phase	Statistically Significant (IDV) Variables (p-value <0.05)	Sub-Categories of Variables (IDVs)	Technologies are Dependent Variable (DV)	β
Pre	Evacuation vehicles	Boat/helicopter/ airplane	Messengers	1.9
		Cycle/motorcycle/ car	Messengers	1.9
	Police	Not preferred	Facebook	3.1
	Socially active	Yes	Combination of ICTs	1.0
	Police	Not preferred	YouTube	1.2
		Not preferred	Contributory websites/ blogs/vlogs	3.1
	Government authority	Not preferred	Combination of ICTs	–2.4
During	Awareness about authorities	Yes	Landline/mobile phone	–1.4
	Vehicle used in routine	Not used/ Not familiar	Mobile phone subscriptions	–3.9
	Police	Not preferred	Mobile phone subscriptions	4.1
	Occupation	Full/part time employed	Mobile phone subscriptions	–3.6
	Vehicle technology In-built	Do not know/None	Messengers	–1.2
	Socially active	Yes	Combination of ICTs	2.0
	Education	School/college grads	GPS trackers	2.6
	Police	Not preferred	Facebook	–1.7
	Emergency/Rescue authorities	Not preferred	Facebook	–1.7
	Vehicle used in routine	Cycle/motorcycle/ car	Contributory websites/ blogs/vlogs	–2.1
		Cycle/motorcycle/ car	Combination of ICTs	–2.2
		No access to public transport vehicle	Combination of ICTs	1.7
	Police	Not preferred	Local news channels	–1.5

(Continued)

Table 1: Continued.

Phase	Statistically Significant (IDV) Variables (p-Value <0.05	Sub-Categories of Variables (IDVs)	Technologies Dependent Variable (DV)	β
Post	Emergency/Rescue authorities	Not preferred	Landline/mobile phone	−2.1
		Not preferred	Combination of ICTs	−2.5
	Awareness about authorities	yes	Emails/ Brochures	−3.1
		yes	Mobile ph. subscriptions	2.0
	Gender	Male	Messengers	−1.2
	Emergency/Rescue authorities	Not preferred	Messengers	−0.9
	Police	Not preferred	Contributory websites/ Apps	2.6
	Emergency/Rescue authorities	Not preferred	GPS trackers	−2.2
	Socially active	Yes	Combination of ICTs	1.3
	Police	Not preferred	Combination of ICTs	−1.2
	Dependency status	Alone	Combination of ICTs	1.5
	Emergency/rescue authorities	Not preferred	Contributory websites/ blogs/vlogs	−2.0
	Evacuation vehicles	Not preferred	Combination of ICTs	−1.7
	Occupation	Student/Home maker	Combination of ICTs	2.1

Results and Discussion

Results from models showed that, for *simple ICTs* no significant pre-flood model emerged however, during-flood lack of awareness regarding authorities increased reliance on landline/mobile phones for transport-flood information, while post-flood dependence on emergency/rescue authorities reinforced the use of conventional ICT channels. For *subscription* services via phone and emails no significant pre-flood association was found, during-flood ICT choice was jointly influenced by routine vehicle availability, reliance on police, and occupation, increasing mobile subscription use among vehicle-owning, unemployed/retired, and police-dependent individuals, whereas post-flood unawareness of relevant authorities reduced reliance on email and mobile subscriptions. For *smart phone messengers* across flood phases, evacuation vehicle type and in-built ICTs significantly shaped messenger use, with pre/during-flood reliance on rescue/private vehicles and embedded-tools (radio, GPS) enhancing adoption. In post-flood female respondents and those relying on emergency/rescue authorities exhibited higher engagement for community-based information exchange. For *smart phone applications*, pre-flood socially active individuals adopted diverse smartphone applications, during-flood school/college graduates demonstrated higher application usage than university graduates/professionals, and post-flood combined reliance on police and emergency/rescue authorities selectively increased GPS-based and contributory update application use. For *social media public forums*, ICT choices across phases were shaped by varying combinations of police reliance, emergency/rescue authorities, social activeness, and dependency status, with pre-flood self-reliant socially active individuals using Facebook/Twitter, during-flood authority-dependent users preferred Facebook, and post-flood socially active, police-dependent individuals engaged both platforms for autonomous information dissemination. For *social media websites*, pre-flood police-dependent individuals exchanged information via YouTube and contributory websites/blogs/vlogs, during-flood mixed-vehicle evacuations' contexts increased the of contributory and multiple social media websites, while post-flood reliance on emergency/rescue authorities and evacuation modes amplified structured information redistribution through online platforms. For *national and international news channels* pre- and post-flood phases were characterized by reliance on both local and international news channels, whereas during-flood information demand narrowed to local channels, with government authorities and police acting as indirect influencing factors and post-flood preferences varying by occupation, particularly among students and homemakers.

From the results it can be inferred that, due to lack of awareness about a specific authority for transport-flood information, people of Head-Marala increased reliance on landline/mobile phones to contact peers during floods, while in the post-flood phase they became more dependent on and trusting of emergency/rescue authorities, yet continued using simple and conventional ICT that remained accessible across diverse mental, physical and social capabilities and strengthened community cohesion through morally driven information sharing.

It was evident that the uncertainty regarding the most appropriate source and type of transport-flood information led people to explore multiple subscription-based services (email and mobile), which facilitated informed travel decisions particularly during-flood. Although internet disruptions limited email effectiveness, and such services proved especially supportive for unemployed/retired individuals and those who had evacuation vehicle access, as subscriptions conveyed operational details about vehicle availability, scheduling and evacuation logistics. The information disseminated through subscription services by transport-flood authorities primarily concerned route diversions, road closures, and availability/non-availability of transport and rescue vehicles, thereby, directly influenced travel decisions, mode choice and destination planning among affected communities.

Flood-affected individuals were aware of the type of transport-flood information obtainable via subscriptions and their available evacuation vehicle options both private or authority-provided, and this vehicle accessibility shaped their motivations to consult subscription updates regarding schedules, diversions and route guidance. Smart phone messengers facilitated one-to-one communication within close social circles in pre- and during-flood phases, which enabled exchange of experiential transport-flood information related to public transport availability, evacuation shuttle services, diverted or blocked routes, a few para-transit options, while near real-time updates obtained from vehicle in-built ICTs such as radio traffic channels and GPS trackers were further redistributed through messengers.

Information acquired from radio commentary and GPS-based real-time guidance was subsequently cascaded through messengers to wider community members. Females demonstrated comparatively higher engagement in disseminating transport-flood information, thereby, actively contributed to community strength and resilience through rapid intra-community communication. Personal traits, particularly social skills and education, significantly influenced smartphone applications usage in pre- and during-flood phases, where individuals independently sought guidance and showed limited reliance on police/government sources, and expressed comparatively greater trust in emergency/rescue authorities. Regarding social media public forums, pre-flood reliance on police-associated Facebook pages shifted during-flood towards intensified authority-based information exchange primarily via Facebook, that reflected adaptive community-authority coping mechanisms, while outside the critical during-flood phase, both Twitter and Facebook were used depending on contextual suitability of ICTs for sustaining transport-flood information flow. The combined availability of mixed evacuation vehicles and transport services under flood conditions influenced selection of specific social media websites, such as mode-specific information e.g bus schedules, blocked roads, disrupted networks, shuttle services, and ambulances that prompted targeted website usage and information issued by emergency/rescue authorities through these platforms was widely trusted by Head-Marala residents. Educational mobility patterns such as school/college/university trips and household roles shaped preferences for news channels, with during-flood reliance on police-communicated transport-flood information via local news channels, forming the basis for the overall conclusions drawn subsequently.

CONCLUSION

The findings presented here are the first ever study of the use of ICT by the flood prone community of Head-Marala, particularly concerning the timely exchange of transport-flood information. It is concluded that the deployment of a mix of ICTs is a practical solution in forming an efficient transportation system that is flood resilient. With limited number of operational ICTs increase substantial increase in congestion in information flow which then leads to a delay in ERSO (Sakano et al., 2013). Whilst different ICTS may be operational in floods of different severity (Miao and Popp, 2014; Ozguven and Ozbay, 2013), simple ICT can accommodate increased demand from a large number of people, and people also find them easy and affordable to use, particularly, in case of communities like Head-Marala. Research shows that disasters involving water (such as floods), can be managed and people can be saved by delivering information through subscribed services such as texting and emails (Priscoli and Hiroki, 2015). In the case of Head-Marala, subscription services (especially mobile phone services), were more reliable than email subscriptions, but that depends on the condition of the infrastructure. Engaging with updated, relevant and timely information was found helpful to flood affected people in the process of evacuations from the flooded area.

However, the exact message to be delivered in the subscribed text needs to be designed carefully by the authorities with inclusion of event specific information rather than general information. The frequency of text messages and the language of the text needs further considerations to precisely define the content of the text. A separate unit consisting of experts who are aware of the needs and capabilities of the local people both physically and in terms of their level of ICT usage skills is required to deal with such an information delivery system in a proficient manner.

In Head-Marala, females seemed active participants in circulating transport-flood information through messengers. Messengers were used to develop peer to peer communication and although these are of a very simple level of technology yet they proved very helpful especially when the functionality of other ICTs were negatively impacted by disasters (Santos et al., 2016). Strong community resilience was also evident as a result of strengthened community networks and relationships through messengers, particularly, which is an important part of the community resilience process irrespective of any particular technology used (Patel et al., 2017). Research has shown that radio (Lefeuvre and Tanzi, 2014) and GPS trackers (Zakia et al., 2016) have been used in disaster management. In Head-Marala radio and GPS trackers were used to seek guidance for evacuation. However, it is still needed to design local transport-flood applications that are event-specific, very localized and can deliver real-time information to transport-flood affected people. Governments in certain parts of the world are designing policies to seriously engage big data, and specifically social media, in disaster management (Kim et al., 2014; Landwehr and Carley, 2014). The people of Head-Marala used Facebook frequently and Twitter occasionally, which is in line with the pattern of usage seen in other case studies internationally (White, 2014). The type of information that could be delivered through these two social media forums needs careful consideration in terms of both content and the users engaged. The reliability of transport-flood information delivered through social media website sources was supportive to the flood affected people of Head-Marala in becoming more organized in a timely manner. The interface design for information websites should be easily understandable by flood affected people (Wang and Ma, 2014). In addition, information should be published in multiple local and international languages and using signs/symbols. Authorities are the key factor influencing the choice of ICT in almost all the post-flood phase models. The community of Head-Marala used their personal capabilities in managing transport-flood information independently and the role of the authorities was largely ambiguous to them. Event specific information with both major and minor levels of details were required. Whilst local news channels were providing generalized information which was of little help.

Overall, there is an absence of organized transport-flood information for the residents of Head-Marala. People were not aware of any authority that could provide them with relevant information in a timely manner. As a result, individuals necessarily relied on emergency authorities for information, who were already heavily engaged in their primary duties (i.e. working on the front line). This reliance created an extra burden on the emergency/rescue authorities and indicated a shift in responsibility from the local authority to the emergency/rescue authorities, albeit unintentional. The need for trained staff to cope with transport-flood scenarios has historically been given scant attention, and this is the right time to address it as a priority. Local news channels and similar platforms can effectively play a part in training community members.

This study identified phase-specific ICT suitability across diverse user capabilities, highlighted community training requirements and institutional role gaps, and provided an evidence base for transport-flood managers and policy makers to develop need-responsive policies, equitable responsibility allocation, and structured guidance frameworks. Future research should focus on standardized ICT communication templates, enhanced user engagement with digital platforms, and the establishment of an expert-managed centralized unit to ensure integrated, real-time, and uninterrupted transport-flood information dissemination.

REFERENCES

Albert, A. and J. Anderson, *On the existence of maximum likelihood estimates in logistic regression models*. Biometrika, 1984. 71(1): pp. 1–10.

Anwer, I., *Factors Limiting the Scope of ITS Technologies in Disaster Relief Operations*. 2016.

Anwer, I., M.I. Yousuf, and S. Grant-Muller, *Evaluation of Barriers to Deployment of Information and Communication Technologies to Sustain Information and Communication Flow in Floods*. Applied Sciences, 2024. 14(2): p. 592.

Anwer, I., S. Grant-Muller, and F. Lai. *Factors Limiting the Scope of Intelligent Transport System Technologies in Disaster Relief Operations*. in *European Transport Conference 2016 Association for European Transport (AET)*. 2016.

Anwer, I., *The role of ITS and Other Advanced Communication Technologies in Reducing the Transport Impacts of Disasters*. 2017, University of Leeds.

Anwer, I. and M.I. Yousuf, *Mapping Undermined Role of Information and Communication Technologies in Floods*. Transport and Telecommunication, 2022. 23(2): pp. 168–179.

Anwer, I. and S. Grant-Muller, *The use of ITS technologies to manage transport in disasters, 12th ITS European Congress, Strasbourg, France, 19-22 June 2017*. 2017b.

Anwer, I. and S. Grant-Muller. *Perceptions Towards the Use of Intelligent Transport System Technologies by Earthquake Victims*. in *International Conference on Applied Human Factors and Ergonomics*. 2017a. Springer.

Authority, D.D.M., *Disaster Risk Management Plan, District Sialkot Government of Punjab*. 2008.

Awan, S.A., *Pakistan: Flood Management - River Chenab From Marala to Khanki*. (Flood Forecasting Division, Pakistan Meteorological Department).

Bull, S.B. and A. Donner, *The efficiency of multinomial logistic regression compared with multiple group discriminant analysis*. Journal of the American Statistical Association, 1987. 82(400): pp. 1118–1122.

Chatterjee, K., et al., *Driver response to variable message sign information in London*. Transportation Research Part C: Emerging Technologies, 2002. 10(2): pp. 149–169.

Chen, X.-Z., et al., *Analysis of transportation network vulnerability under flooding disasters*. Transportation Research Record: Journal of the Transportation Research Board, 2015(2532): pp. 37–44.

Faturechi, R. and E. Miller-Hooks, *Travel time resilience of roadway networks under disaster.* Transportation Research Part B: Methodological, 2014. 70(0): pp. 47–64.

Field, A., *Discovering statistics using IBM SPSS statistics*. 2013: Sage.

Giovanna, C., et al., *Transport models and intelligent transportation system to support urban evacuation planning process*. IET Intelligent Transport Systems, 2016. 10(4): pp. 279–286.

Grant-Muller, S. and M. Usher, *Intelligent Transport Systems: The propensity for environmental and economic benefits*. Technological Forecasting and Social Change, (0).

Gutman, G.M. and Y. Yon, *International Journal of Disaster Risk Reduction*. 2014.

Hashmi, H.N., et al., *A critical analysis of 2010 floods in Pakistan*. African Journal of Agricultural Research, 2012. 7(7): pp. 1054–1067.

Hedeker, D., *A mixed-effects multinomial logistic regression model*. Statistics in medicine, 2003. 22(9): pp. 1433–1446.

Hosmer, D.W. and S. Lemeshow, *Introduction to the logistic regression model*. Applied Logistic Regression, Second Edition, 2000: pp. 1–30.

J. Brian Houston, J.H., Mildred F. Perreault, Eun Hae Park,, M.R.H. Marlo Goldstein Hode, Sarah E. Turner McGowen,, and S.V. Rachel Davis, Jonathan A. McElderry, and Stanford A. Griffith, *The Use of Social Media for Disaster Recovery.* 2014.

Jerry Velasquez, D., et al., *Grass-root preparedness against potential flood risk among residential and commercial property holders*. International Journal of Disaster Resilience in the Built Environment, 2015. 6(1): pp. 44–56.

Kim, G.-H., S. Trimi, and J.-H. Chung, *Big-data applications in the government sector.* Communications of the ACM, 2014. 57(3): pp. 78–85.

Landwehr, P.M. and K.M. Carley, *Social Media in Disaster Relief*, in *Data Mining and Knowledge Discovery for Big Data: Methodologies, Challenge and Opportunities*, W.W. Chu, Editor. 2014, Springer Berlin Heidelberg: Berlin, Heidelberg. pp. 225–257.

Lefeuvre, F. and T.J. Tanzi, *Radio science's contribution to disaster emergencies*. The Radio Science Bulletin, 2014. 348: pp. 37–46.

Lemeshow, S., Hosmer, D, *Applied Logistic Regression (Wiley Series in Probability and Statistics)*. Vol. 2. 2000: Wiley-Interscience Hoboken.

Miao, Q. and D. Popp, *Necessity as the mother of invention: Innovative responses to natural disasters*. Journal of Environmental Economics and Management, 2014. 68(2): pp. 280–295.

Muller, A. and G. Whiteman, *Exploring the geography of corporate philanthropic disaster response: A study of Fortune Global 500 firms*. Journal of Business Ethics, 2009. 84(4): pp. 589–603.

Ozguven, E.E. and K. Ozbay, *A secure and efficient inventory management system for disasters*. Transportation Research Part C: Emerging Technologies, 2013. 29: pp. 171–196.

Patel SS, R.M., Amlôt R, Rubin GJ., *What Do We Mean by 'Community Resilience'? A Systematic Literature Review of How It Is Defined in the Literature*. 2017

Priscoli, J.D. and K. Hiroki, *Water and Disasters: Cases from the High Level Experts and Leaders Panel on Water and Disasters*. 2015, IWA Publishing.

Sakano, T., et al., *Disaster-resilient networking: A new vision based on movable and deployable resource units*. IEEE Network, 2013. 27(4): pp. 40–46.

Santos, J.V., et al. *Rapid mobile development with ARC: Application framework for robust communications for disaster risk reduction and management*. in *Wireless and Mobile Computing, Networking and Communications (WiMob), 2016 IEEE 12th International Conference on*. 2016. IEEE.

Shafiq, F. and K. Ahsan, *An ICT based Early Warning System for Flood Disasters in Pakistan*. Research Journal of Recent Sciences ISSN, 2014. 2277: p. 2502.

Societies, I.F.o.R.C.a.R.C., *World Disasters Report* 2015.

Starkweather, J. and A.K. Moske, *Multinomial logistic regression*. Consulted page at September 10th: http://www. unt. edu/rss/class/Jon/Benchmarks/MLR_JDS_Aug, 2011. pdf, 2011.

Tortora, R.D., *A note on sample size estimation for multinomial populations*. The American Statistician, 1978. 32(3): pp. 100–102.

Tribune, T.E., *World Disasters Report 2013: Use of technology enhances resilience of disaster-prone communities* - December 11, 2013.

Wang, Z. and S. Ma. *Web Information Search in Emergency Rescue under Disasters*. in *Computational Intelligence and Communication Networks (CICN), 2014 International Conference on*. 2014. IEEE.

Wedagama, D.P., *A multinomial logit model for estimating the influence of household characteristics on motorcycle ownership: A case study in Denpasar city, Bali*. Journal of Civil Engineering, 2009. 29(1): pp. 2–9.

White, E.T., *The Application of Social Media in Disasters*. International Institute of Global Resilience, 2014.

Zakia, U., et al. *A Navigation system for rescue operation during disaster management using LTE advanced network and WPAN*. in *Information Technology, Electronics and Mobile Communication Conference (IEMCON), 2016 IEEE 7th Annual*. 2016. IEEE.

Zear, A., P.K. Singh, and Y. Singh, *Intelligent transport system: A progressive review*. Indian Journal of Science and Technology, 2016. 9(32).